Oct. 12, 1954 G. D. STEWART 2,691,312

BORING AND TURNING MACHINE AND FIXTURE FOR GENERATING VARIOUS PREDETERMINED SURFACES OF REVOLUTION

Filed Sept. 20, 1950

6 Sheets-Sheet 1

Fig. 2

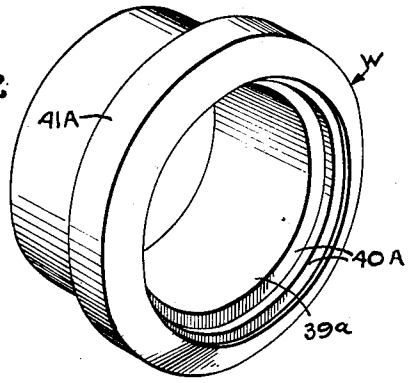
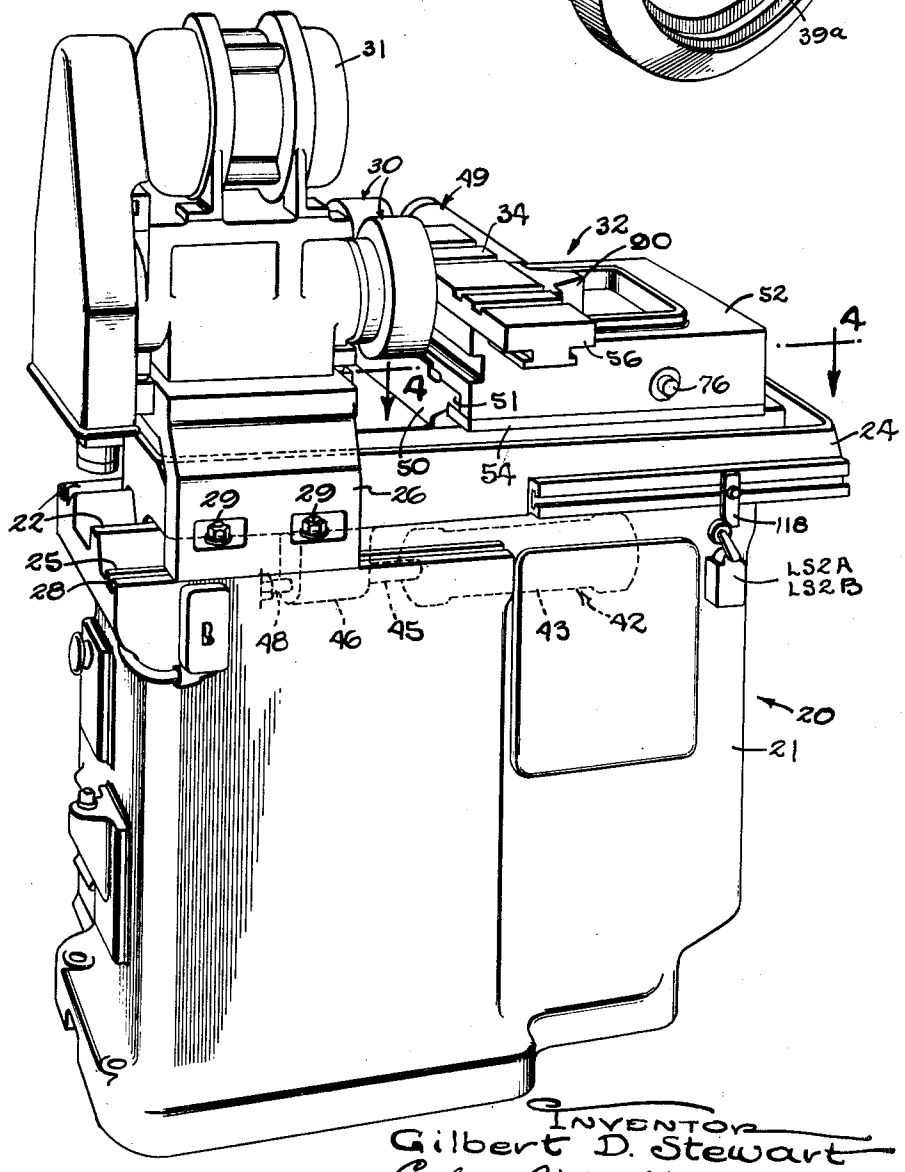


Fig. 1



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6 Sheets-Sheet 2

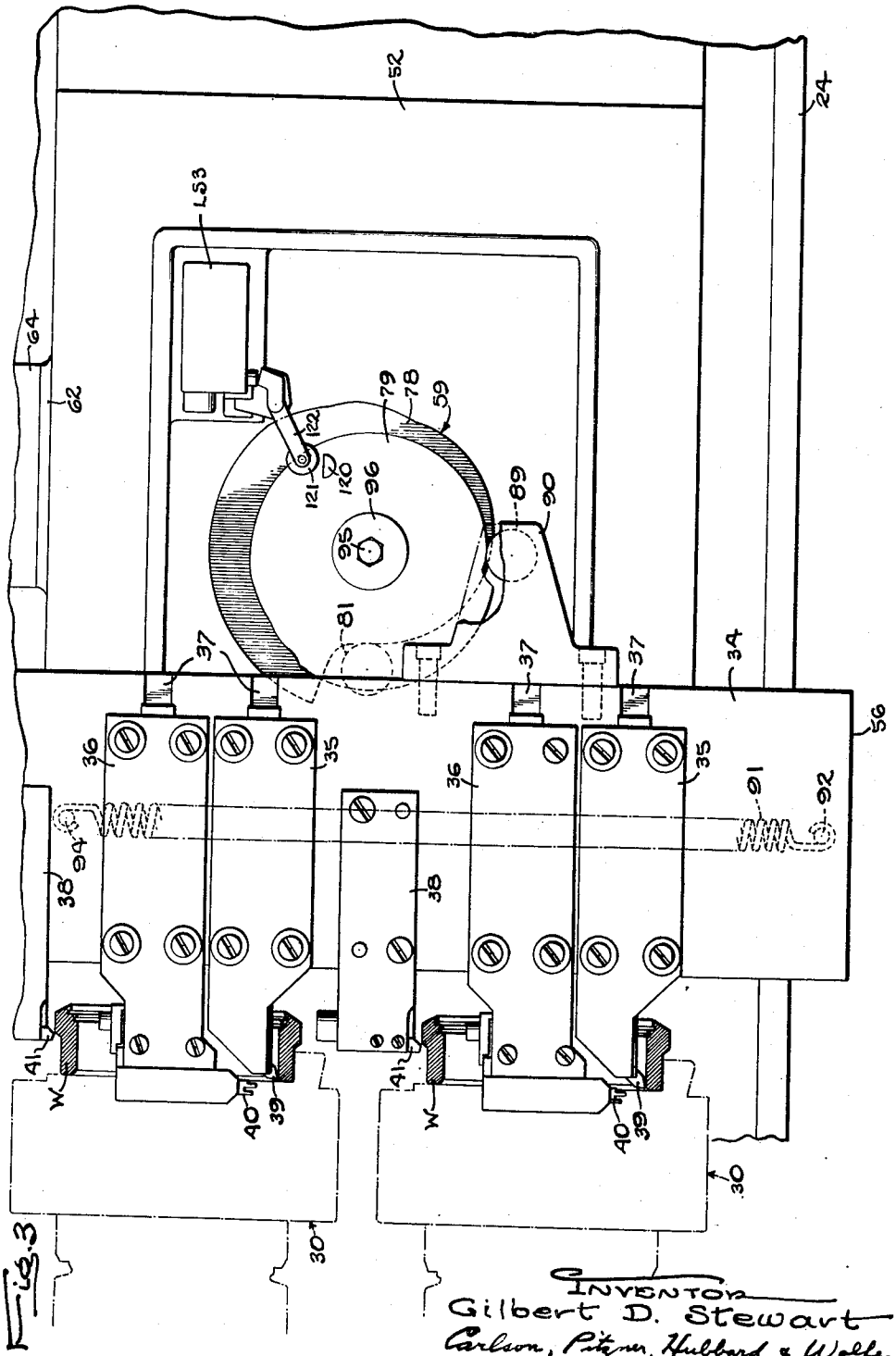


Fig. 3

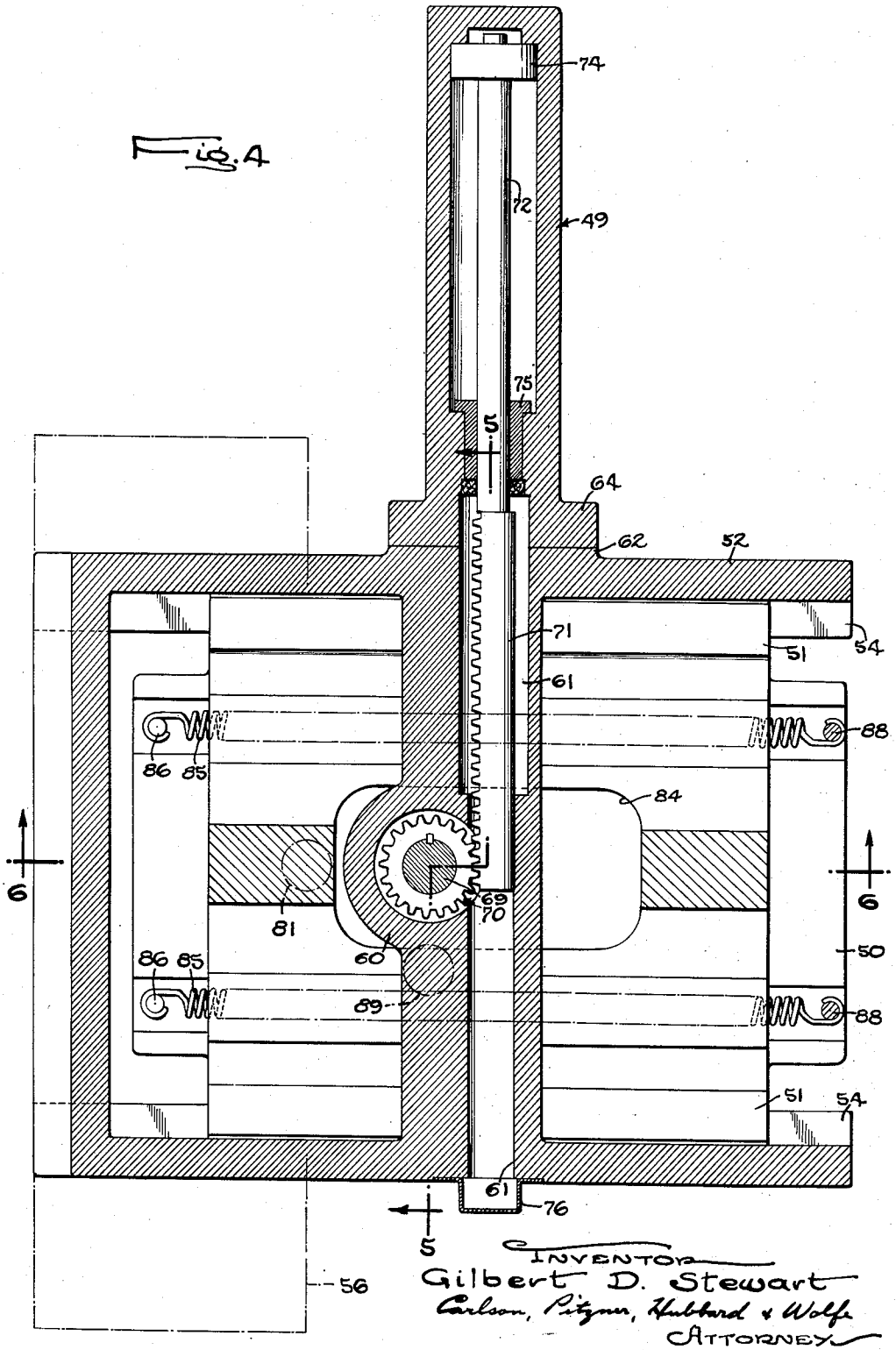
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Fig. 4



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Fig. 5

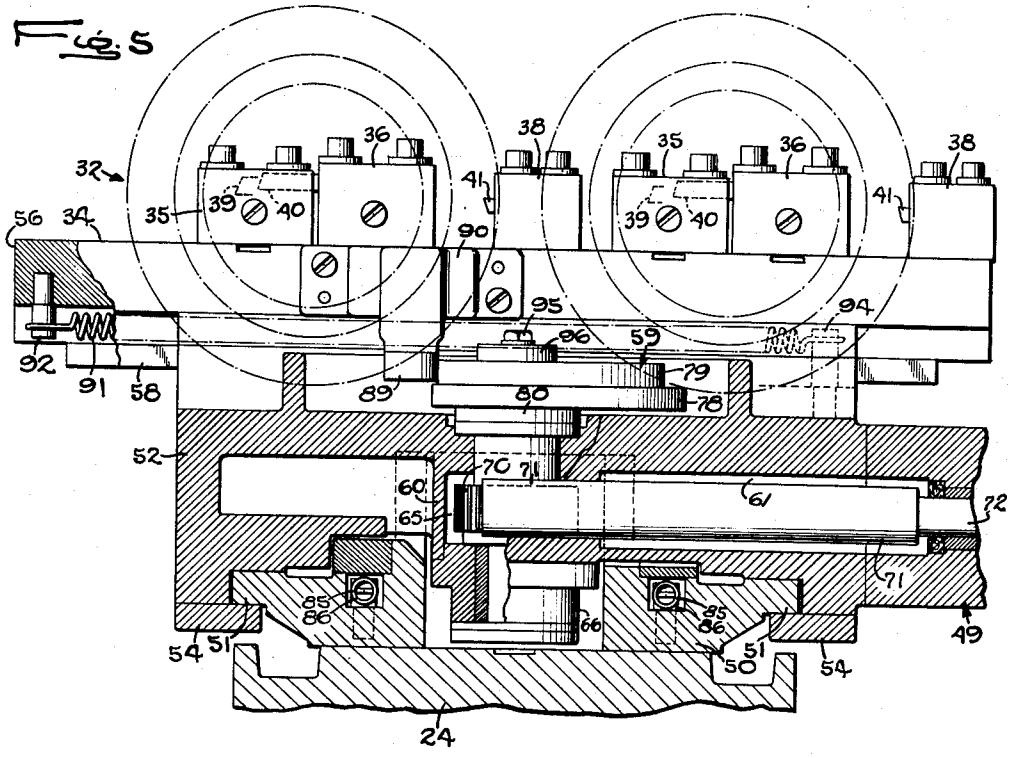
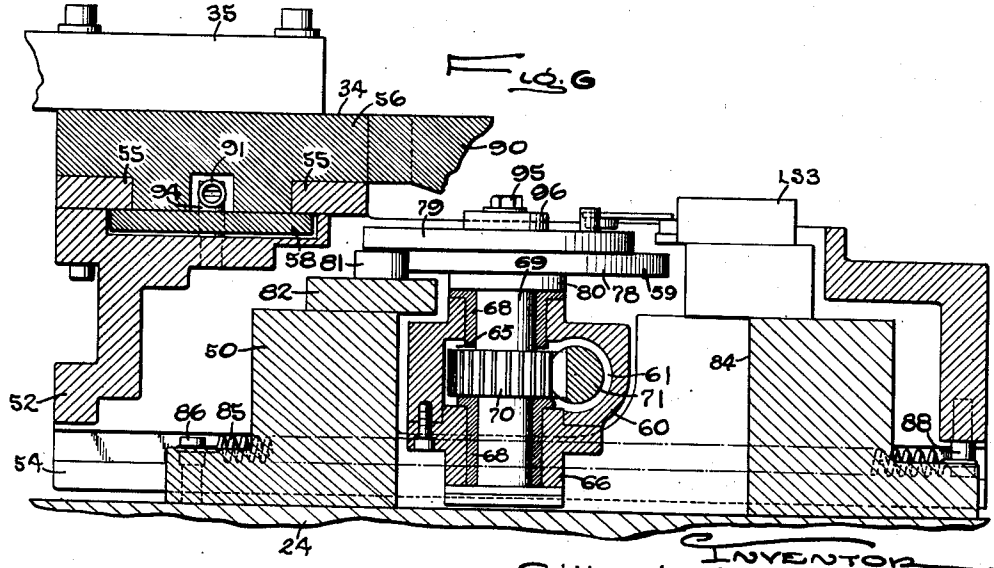


Fig. 6



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BORING AND TURNING MACHINE AND FIXTURE FOR GENERATING VARIOUS PREDETERMINED SURFACES OF REVOLUTION

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Fig. 7

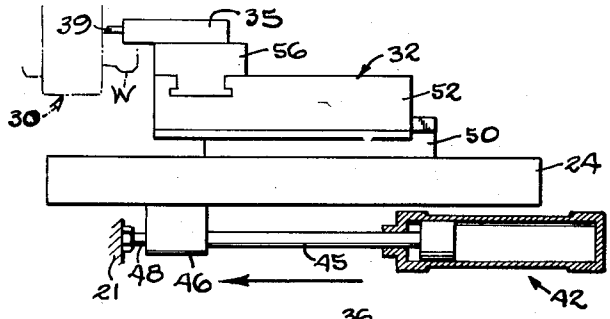


Fig. 8

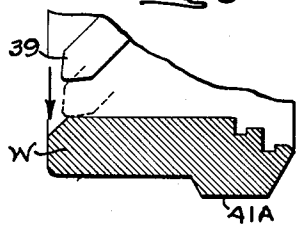


Fig. 9

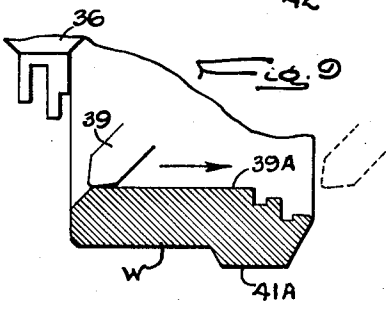


Fig. 10

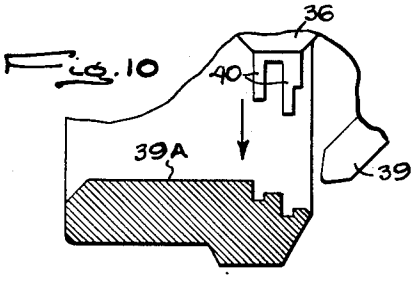


Fig. 11

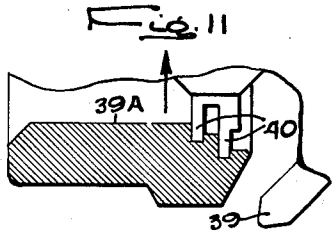


Fig. 12

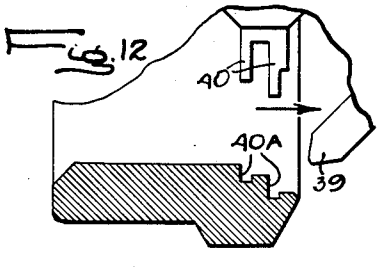


Fig. 13

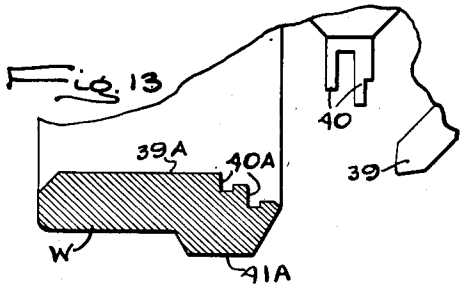
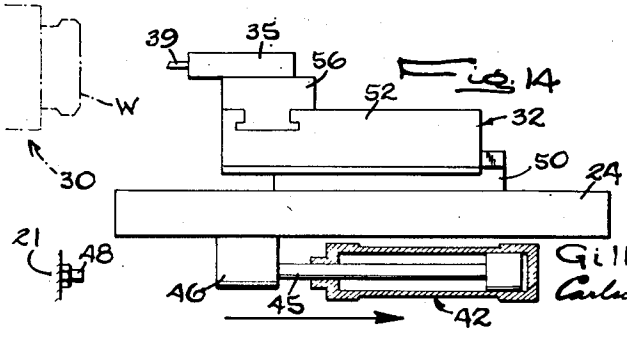


Fig. 14



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Filed Sept. 20, 1950 6 Sheets-Sheet 6

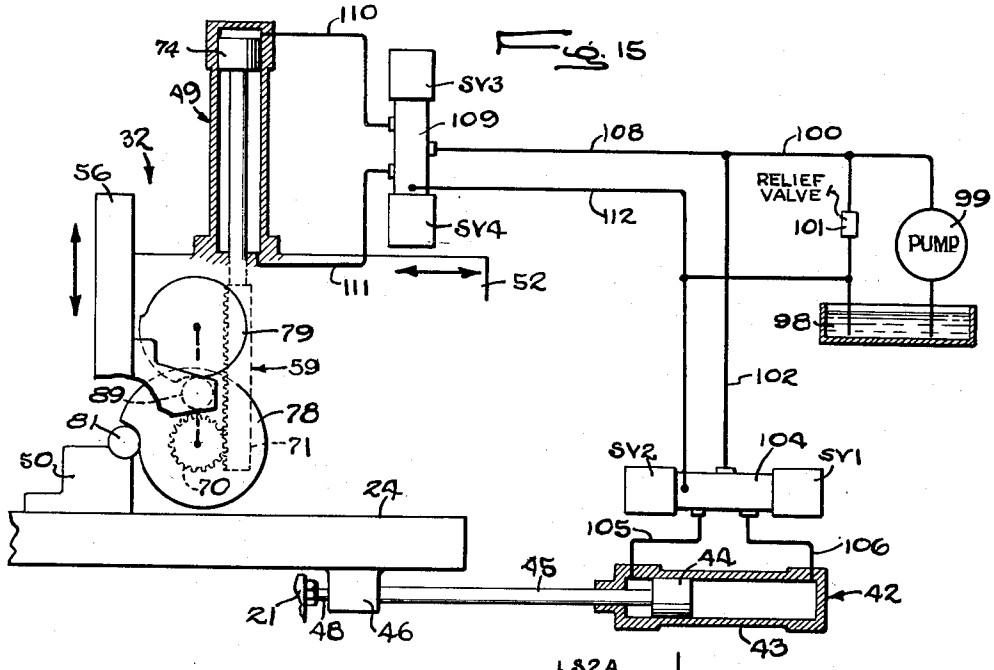


Fig. 15

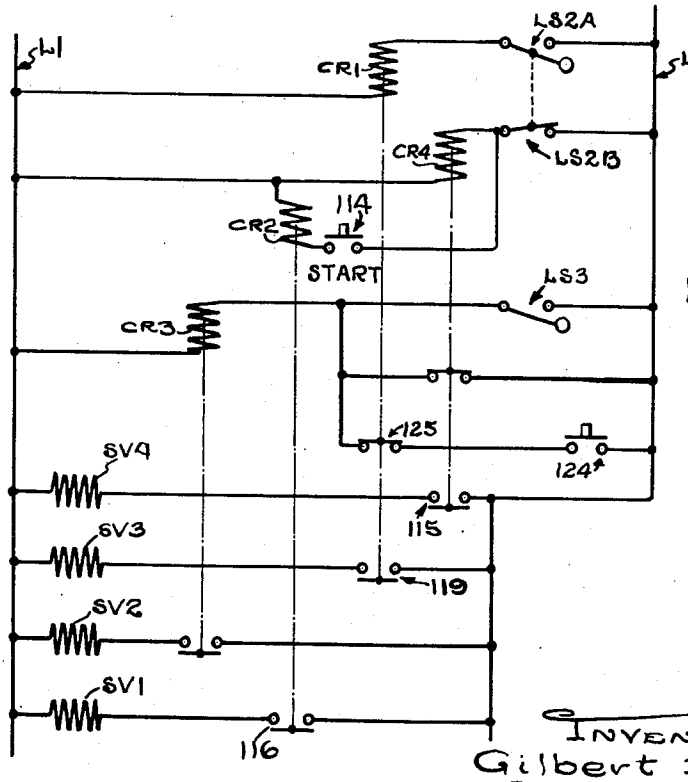


Fig. 16

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UNITED STATES PATENT OFFICE

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BORING AND TURNING MACHINE AND FIXTURE FOR GENERATING VARIOUS PREDETERMINED SURFACES OF REVOLUTION

Gilbert D. Stewart, Detroit, Mich., assignor to Ex-Cell-O Corporation, Detroit, Mich., a corporation of Michigan

Application September 20, 1950, Serial No. 185,859

8 Claims. (Cl. 77—3)

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The present invention pertains generally to machine tools and more particularly to a novel and improved boring and turning machine of the general type disclosed in U. S. Patent No. 2,158,060, issued May 16, 1939, to Carroll R. Alden. In one of its more specific aspects, the invention is also concerned with a novel tool or work supporting fixture finding particular but by no means exclusive utility in a boring and turning machine of the type shown in the foregoing patent.

One object of the invention is to provide a boring and turning machine having hydraulically actuated tool carrying or work carrying elements and including a novel means for correlating the movements of such elements to generate any desired surface of revolution in a workpiece.

Another object is to provide a machine of the character set forth and having means for imparting simultaneously to a tool point any desired combination of velocities along rectangular or other coordinates, enabling the tool point to generate upon a relatively rotatable workpiece any predetermined surface of revolution.

A further object is to provide a boring and turning machine of the foregoing type and which will be susceptible of wide changes in the sequence, direction and velocity of movement of the tool or work carrying elements by simply interchanging certain readily accessible cam members.

Another object is to provide a novel tool or work supporting fixture having utility in a machine of the type set forth and comprising a plurality of relatively movable, coordinated tool carrying or work carrying elements. A related object is to provide a fixture susceptible of attachment upon the longitudinally movable table of the boring and turning machine for rapid traverse and return between an idle position and a working position.

Other objects and advantages will become apparent as the following description proceeds, taken in the light of the accompanying drawings, wherein:

Figure 1 is a front perspective view of an illustrative boring and turning machine embodying the present invention.

Fig. 2 is an enlarged perspective view detailing an annular workpiece having surfaces of revolution generated on the machine of Fig. 1.

Fig. 3 is an enlarged fragmentary plan view illustrating the tooling of the machine of Fig. 1 and showing the work in horizontal section.

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Fig. 4 is an enlarged horizontal sectional view through one of the slide members of the tool or work supporting fixture on the machine shown in Fig. 1, such view being taken on plane 4—4 of Fig. 1.

Figs. 5 and 6 are vertical sectional views through the tool or work supporting fixture, such views being taken in the planes of the lines 5—5 and 6—6, respectively.

Figs. 7 to 14, inclusive, are diagrammatic, stop-motion views illustrating the cycle of tool movements in the illustrative boring and turning machine.

Fig. 15 is a diagrammatic view showing one form of hydraulic system applicable to the machine of Fig. 1 and also indicating the relation between such system and the tool or work supporting fixture on the machine.

Fig. 16 is a diagrammatic view of one form of electrical control system applicable to the machine of Fig. 1.

While the invention is susceptible of various modifications and alternative constructions, a preferred embodiment has been shown in the drawings and will be described below in considerable detail. It should be understood, however, that there is no intention to limit the invention to the specific form disclosed, but on the contrary, the intention is to cover all modifications and alternative constructions and equivalents falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more specifically to the drawings, there is shown in Fig. 1 an exemplary boring and turning machine 20 embodying the present invention. The machine 20 is built upon an elongate hollow base 21 having formed on its top a pair of ways 22 which extend from side to side and slidably support a longitudinally movable table 24. Outboard of the ways 22, the base 21 is provided with a second pair of ways 25 somewhat shorter in length than the ways 22. The ways 25 slidably support a bridge or saddle 26 adapted to straddle the left-hand end portion of the table 24 (as viewed in Fig. 1). The bridge 26 may be secured in various positions of adjustment along the ways 25 as by means of T-slots 28 and drawbolts 29. Fixedly supported on the bridge 26 are a pair of spindles 30 driven as by means of an electric motor 31 and each adapted in the present instance to rotatably support an annular workpiece W having a finished shape as shown in Fig. 2. The machine table 24 has mounted thereon a tool or work supporting fixture 32 including relatively movable tool or work

supporting members. While the fixture 32 is adapted equally well to bring work into engagement with tools carried by the spindles 30 or, on the other hand, to bring tools into engagement with work mounted in the spindles 30, the latter arrangement happens to be the one utilized in the machine 20 and will be described below. Those skilled in the art will, however, appreciate that the structure described herein possesses sufficient versatility to permit the use of either of such arrangements.

Running generally transversely of the longitudinal axis of the machine 20 and the axes of the spindles 30 is a substantially horizontal tool support deck 34 defined by the fixture 32. In this instance, the tool support deck 34 is adapted to carry a plurality of tool holders 35, 36, 38, being provided with suitable mounting slots 37 and tapped holes to permit fastening of the tool holders thereto in a wide variety of positions (see Fig. 3). Each group of the tool holders 35, 36, 38 is adapted to carry an assortment of tool points for operating upon one of the workpieces W carried by a corresponding one of the spindles 30. In this instance, the workpieces are initially rough cut to the general shape indicated in Fig. 2 although this is not a necessity. Since the two groups of tool holders and the two workpieces are identical, a description of one group of tool holders and one workpiece will suffice for all. Referring more particularly to Figs. 2 and 3, it will be perceived that the tool holder 35 carries at its projecting end a boring tool 39 which is adapted to finish bore 39A of the workpiece W. Similarly, the tool holder 36 supports at its projecting end a double pointed grooving tool 40 which is adapted to finish the closely spaced grooves 40A adjacent the outboard end of the workpiece W. The tool holder 38 is provided with a turning tool 41 which is adapted to take a finishing cut on the outer peripheral surface 41A of the shoulder adjacent the outboard end of the workpiece W. To preclude the possibility of accumulating chips on top of the cutting edges, the boring and grooving tool points 39, 40 are preferably formed with their cutting edges on their undersides, the workpiece W being rotated by the spindle 30 in a clockwise direction, as viewed from the right-hand end of the machine 20.

Provision is made for rapidly traversing the fixture 32, together with the tool points 39, 40 and 41, between an idle or work loading position at the right-hand end of the machine 20 and a working position in the vicinity of the spindles 30. This is accomplished by the use of a hydraulic actuator 42 secured within the machine base 21 and comprising a cylinder 43 which slidably houses a piston 44 and piston rod 45. The free end of the piston rod 45 is rigidly secured to a depending abutment 46 fixed to the machine table 24 (see Figs. 1, 14 and 15). The idle position of the table 24 and fixture 32 is in this instance defined by the extreme right-hand position of the piston 44 within the cylinder of the actuator 42. The extreme left-hand working position of the table 24 and fixture 32 is, however, defined as by means of an adjustable mechanical stop 48 secured within the machine base 21 in an appropriate position to intercept the table abutment 46. The stop 48, of course, precludes interference between the fixture or tool points and the spindles 30, being made adjustable because the spindle supporting bridge 26 is itself adjustable relative to the base 21.

For the purpose of coordinating the movements of the tool points 39, 40 and 41 with the relatively rotatable workpiece W so as to generate upon the latter one or more surfaces of revolution of any desired configuration, provision is made in the fixture 32 for imparting various combinations of longitudinal and transverse velocity components to the tool points by the use of a single hydraulic actuator 49 (see Figs. 1, 4, 5 and 15). The fixture 32 is accordingly fashioned with a bed 50 bolted or otherwise rigidly secured to the table 24 and bodily movable therewith. The fixture bed 50 is provided with a pair of ways 51 extending substantially parallel to the table ways 22 on the machine bed 21. Supported on the ways 51 for movement relative to and substantially parallel to that of the table 24 is a longitudinal slide 52, the latter being held down as by means of plates 54 which engage the undersides of the ways 51. In its upper region and adjacent its left-hand end (as viewed in Fig. 1), the longitudinal slide 52 is formed with a pair of transverse guideways 55 which slidably receive the underside of a cross slide 56 held on the ways 55 as by means of a bottom plate 58 (Fig. 6). The upper surface of the cross slide 56 defines the tool support deck 34 already described above. In the foregoing structure, it will be perceived that the entire fixture 32, including the longitudinal slide 52, the cross slide 56 and the tools thereon, is bodily movable with the table 24 longitudinally of the ways 22 on machine base 21. By the same token, the longitudinal slide 52 and the cross slide 56 are bodily movable as a unit with respect to the table 24 as well as the fixture bed 50 and in a direction substantially parallel to the axis of table movement. In addition, the cross slide 56 is movable relative to and transversely of the table 24, the fixture bed 50 and the longitudinal slide 52, such movement in this instance being perpendicular to the axis of table movement.

In order to permit the single actuator 49 to move the slides 52, 56 in timed relation to each other as well as to the fixture bed 50 and the table 24, the actuator 49 is fixed to the rearward side of the longitudinal slide 52 and resort is had to a novel cam mechanism 59. The slide 52 is accordingly provided with a hollow depending boss 60 (Figs. 4, 5 and 6) and a transverse bore 61 terminating at the rearward side of the slide 52 in a circular pad 62 to which flange 64 of the actuator 49 is attached in any appropriate manner. The hollow boss 60 has a relatively large, stepped vertical bore 65 therein communicating with the bore 61 and closed at its lower end by means of a flanged cap 66 bolted to the boss 60. Journaled within bushings 68 inside the bore 65 and its cap 66 is an upstanding cam shaft 69. Fixed at an intermediate point on the latter is a driving pinion 70 which meshes with a toothed rack 71 of generally circular cross section. In this instance, the rack 71 is made integral with piston rod 72 of the actuator 49, being reciprocated longitudinally of the bore 61 by means of the actuator piston 74 and guided by means of bushing 75 adjacent flange 64 of the actuator. To permit the actuator to shift the rack 71 through a full forward stroke and at the same time protect the operator of the machine, the forward or front end of the bore 61 may be covered as by means of a light stamped sheet metal cap 76 (Figs. 1 and 4).

At its upper end, the cam shaft 69 has detachably but securely fixed thereto a pair of cams

78, 79 which may be axially supported as by means of lateral shoulder 80 integral with the shaft 69. The cam 78 has its profile in engagement with follower roller 81 which is journaled upon a pad 82 rigidly fixed to the fixture bed 50. Thus as the cam 78 is rotated, the longitudinal slide 52 will move relative to the fixture bed 50 along the guideways 51, the bed 50 being provided with a rectangular recess 84 (Figs. 4 and 6) to give the depending boss 60 sufficient clearance. Lost motion between the cam 78 and the roller 81 is eliminated by the use of a pair of spaced apart tension springs 85 anchored at their left-hand ends to pins 86 on the machine bed 50 and at their right-hand ends to pins 88 fixed in the longitudinal slide 52. Turning now to the cam 79, it will be noted that the profile of the same engages a follower roller 89 journaled on a bracket 90 which is fixed to the cross slide 56 (see Figs. 3 and 5). The bracket 90 is so dimensioned that the centers of the roller 89 and cam shaft 69 always remain alined on an axis parallel to the cross slide guideways 55 and in this instance perpendicular to the direction of table movement. Consequently, rotation of the cam 79 will always move the roller 89, and hence the cross slide 56 with its tools, bodily along an axis perpendicular to the axis of movement of the table 24. Lost motion between the cam 79 and the roller 89 is readily taken up by means of tension spring 91 anchored at its front end to pin 92 in the cross slide 56 and at its rearward end to pin 94 fixed to the longitudinal slide 52.

By the use of cams having various predetermined configurations, any conceivable combination of movements which may be executed by controllable components along rectangular or other coordinates may be imparted to the cross slide 56 and the tool points fixed thereto. Moreover, wide changes in the sequence, direction and velocity of such movements may be effected by the simple expedient of changing the cams 78, 79. This may conveniently be done by removing drawscrew 95 and clamping washer 96 which are always readily accessible from the top of the fixture 32. The direction of movement of the longitudinal slide 52 and the cross slide 56 may also be reversed without changing cams, simply by relocating their respective follower rollers in positions 180° away from those shown in the drawings. In the event this is done, it is also necessary to reverse the anchor points for the springs 85, 91 so that they will exert tension in the opposite direction.

Referring next to Figs. 7 to 14, inclusive, a cycle of tool point movements is there illustrated in a series of stop-motion diagrammatic views, such cycle being the one required to create in the workpiece W the finished contours indicated in Fig. 2. For purposes of simplicity in illustration, only the boring and grooving tools 39, 40 have been shown in these views, the turning tool 41 having been omitted. Since the tool 41 is spaced in fixed relation to the boring tool 39 and finishes the outer peripheral surface 41A of the workpiece while the boring tool 39 is finishing the bore 39A, the operation of the turning tool will be readily apparent. Initially, the table 24, along with the fixture 32, is held by the actuator 42 in the idle or right-hand position indicated in Fig. 14. By the same token, the longitudinal slide 52, together with the cross slide 56 and the tool points thereon, occupies its extreme left-hand position relative to the fixture bed 50 and the machine table 24. Pressure fluid is thereupon supplied to the right-hand end of the actuator 42 and exhausted from the left-hand end of the same, traversing the table 24, the fixture 32 and the tool points from their idle position into their extreme left-hand working position as indicated in Fig. 7. Such position is defined by the point of interception between the adjustable stop 48 and the abutment 46 and is so located that the boring tool 39 will be at the innermost end of the bore 39A of the workpiece, clearing the same radially as indicated in Fig. 8. At this time, pressure fluid is admitted to the rearward end of the actuator 49, causing the piston 74 and the rack 71 to move forward and initiate clockwise movement of the cam shaft 69 and the cams 78, 79. Due to a dwell on the cam 78, the longitudinal slide 52 will remain in its left-hand position temporarily. A rise on the cam 79 will, however, cause the cross slide 56 to move transversely toward the front of the machine 20, thereby moving the boring tool 39 radially into cutting position within the bore of the workpiece as indicated in Figs. 8 and 9. A subsequent dwell in the profile of the cam 79 now maintains the boring tool in cutting position, while a corresponding rise in the cam 78 causes the longitudinal slide 52 to move rightwardly relative to the fixture bed 50 and the table 24, the longitudinal slide 52 carrying with it the cross slide 56 and the tool points mounted thereon. This motion continues until the boring tool has finished its cut and reached a position outside the bore 39A as indicated in Fig. 10. A subsequent rise in the cam 79 thereupon effects further forward or outward movement of the cross slide 56, moving the grooving tool 40 radially and plunging the same into the grooves 40A to finish the same to the required depth. Rightward movement of the longitudinal slide 52 is precluded during this period by means of a corresponding dwell on the cam 78. Upon completion of the grooving cut, a relieved portion in the profile of the cam 79 permits the cross slide 56 to be shifted transversely toward the rear of the machine, under the action of tension spring 91. This, of course, moves the grooving tool 40 radially from the position shown in Fig. 11 to that shown in Fig. 12. As soon as the grooving tool 40 has been withdrawn a safe distance from the work, pressure fluid is admitted to the left-hand end of the table actuator 42 and exhausted from the right-hand end thereof. This traverses the table 24, the fixture 32, and the tool points to the right toward their idle position. At the same time, reverse movement of the piston 74 and rack 71 of actuator 49 takes place as the table 24 and fixture 32 are being retracted to the right, reversing the cams 78, 79. Upon arrival of the table and fixture at their idle position, shown in Fig. 14, reverse movement of the actuator piston 74 and the cams 78, 79 will have been completed and the longitudinal slide 52 will have been returned to its leftward position, shown in Fig. 14.

Pressure fluid may be supplied to and exhausted from the actuators 42, 49 by means of the system illustrated in Fig. 15. Thus, fluid is drawn from a reservoir 98 by means of a pump 99 and delivered to a supply conduit 100, the pump being protected by the usual relief valve 101 interposed between the supply conduit 100 and the reservoir 98. A branch conduit 102 conducts pressure fluid from the supply line 100 to double acting control valve 104 which governs the direction of movement of the piston 44 in the actuator 42. The valve 104 is connected with opposite ends of the actuator 42 in the usual way by means of

jumper conduits 105, 106. In the present instance, the valve 104 is operated by means of control solenoids SV1 and SV2 which can be selectively energized to shift the actuator piston 44 in either direction. Similarly, pressure fluid supply conduit 109 is connected via a branch conduit 108 with double acting control valve 109 which governs the direction of movement of the piston 74 of actuator 49. Like the valve 104, the valve 109 is connected to opposite ends of the actuator 49 by means of jumper conduits 110, 111 and is operated by means of control solenoids SV3 and SV4. Pressure fluid exhausted from the actuators 42, 49 is conducted via the valves 104, 109 into an exhaust conduit 112 which discharges into the reservoir 98.

Turning now to Fig. 16, there is illustrated schematically an electrical circuit which is of particular utility in the exemplary machine 20. Such circuit comprises power supply line conductors L1, L2 adapted for connection to any suitable source of electric power. A main starting switch 114 which may be of the normally open pushbutton type is connected in series with contactor CR2 between lines L1, L2 via line switch LS2B, the latter being normally closed when the table 24 is out of working position. Contactor CR4 is also connected in series across the supply lines via the switch LS2B and initially maintains the valve control solenoid SV4 in an energized condition by the closure of switch 115. This admits pressure fluid to the forward end of the actuator 49 and exhausts fluid from its opposite end, maintaining the piston of the same in initial position as shown in Fig. 15. Closure of the main starting switch 114 energizes contactor CR2 which in turn energizes valve control solenoid SV1 through series connected switch 116. This results in the admission of pressure fluid to the right-hand end of the actuator 42 and exhausts fluid from its opposite end, causing the table 24 to traverse leftwardly toward the workpiece W. Such movement continues until the table 24, the fixture 32 and the tool points thereon reach their extreme leftward position (see Fig. 7), at which time dog 118 on table 24 (see Fig. 1) opens limit switch LS2B and simultaneously closes limit switch LS2A. Closure of the switch LS2A accordingly energizes the contactor CR1 which, in turn, energizes the valve control solenoid SV3 via switch 119. This causes valve 109 to admit pressure fluid to the rearward end of the actuator 49 and exhaust it from the forward end, thereby initiating clockwise rotation of the cams 78, 79 (as viewed in Fig. 3) and bringing the boring tool 39 into cutting position as indicated in Fig. 9. By the same token, opening of the limit switch LS2B results in deenergizing of the contactor CR4 and thereby opens normally closed switch 115 to deenergize the solenoid SV4 at the same time the solenoid SV3 is energized. Continued forward movement of the piston 74 of actuator 49 results in further clockwise rotation of the cams 78, 79 and thereby moves the tools through the cycle diagrammed in Figs. 8 to 12 and described earlier herein. When the cams have completed their forward or clockwise cycle, an abutment 120 carried by the cam 79 contacts a roller 121 on operating arm 122 of a limit switch LS3, closing the latter (see Fig. 3). Closure of the switch LS3, which is connected in series with contactor CR3, energizes valve control solenoid SV2 to admit pressure fluid to the left-hand end of the actuator 42 and exhaust it from the opposite end, initiating return movement of the table 24, the fixture 32 and the tool points thereon. As the table starts to return to idle position, the limit switch LS2B closes, energizing the contactor CR4 and thereby energizing the valve control solenoid SV4. This admits pressure fluid to the forward end of the actuator 49 and exhausts fluid from the opposite end, initiating reversal of the cams after the tools have safely cleared the work.

It will be appreciated that the cam construction and controls described above constitute an effective interlock which precludes the undesirable possibility of making a reverse pass of the tool points over the workpiece as the piston of the actuator 49 is being reversed. In instances where it is desired to utilize an initial increment of reverse movement of the piston 74 of actuator 49 to withdraw the grooving tool 40 radially from the work, provision may be made in the control circuit for initiating return movement of the table 24, the fixture 32 and the tool points as soon as the tool 40 has cleared the workpiece and before the cams effect a reverse pass of the tools on the workpiece. This may be readily accomplished by the use of additional limit switches or time delay devices.

A normally open manual switch 124 of the pushbutton type may optionally be provided for moving the table toward its idle position. Thus the switch 124 is connected with the contactor CR3 so as to energize the same upon closure, thereby energizing the valve control solenoid SV2. A safety switch 125 actuated by the contactor CR1 is also connected in series with the manual switch 124 to prevent table movement when the piston of cam actuator 49 is moving forward.

I claim as my invention:

1. A boring and turning machine for generating any desired surface of revolution in a workpiece by moving a tool point relative thereto, said machine comprising, in combination, a base, a spindle fixed to said base, a table reciprocable longitudinally of said base, a first hydraulic actuator connected with said table for reciprocating the same, a supporting fixture mounted on said table and movable bodily therewith, a support deck on said fixture and adapted to carry a tool point and a workpiece alternatively, said support deck being mounted for movement relative to said fixture and said table, a cam shaft journaled within said fixture, a pair of cams fixed to said cam shaft, a pair of cam followers disposed in engagement with respective ones of said cams, each said cam and its associated follower being constructed and arranged to impart to said support deck various predetermined components of movement along a particular one of a pair of coordinate axes, and a second hydraulic actuator positively connected to said cam shaft, said second actuator being mounted on said fixture, electrical control valves for said actuators, means defining a source of pressure fluid for said actuators and a reservoir for exhausted fluid, and an electrical control system for operating said actuators and said support deck in timed relation to each other by means of said electrical control valves.

2. A boring and turning machine for generating any desired surface of revolution in a workpiece by moving a tool point relative thereto, said machine comprising the combination of a base, a spindle fixed to said base, a table reciprocable longitudinally of said base, a hydraulic actuator for reciprocating said table, a supporting fixture mounted on said table and movable bodily therewith, a support deck on said fixture adapted to

carry a tool point and a workpiece alternatively, said support deck being relatively movable with respect to said fixture and to said table, a pair of cams, a pair of cam followers associated with respective ones of said cams, each said cam and its associated follower being constructed and arranged to impart to said support deck various predetermined components of movement along a corresponding one of a pair of coordinate axes, and a second hydraulic actuator connected with said cams for rotating the same in unison, said second actuator being mounted on said fixture.

3. A boring and turning machine for moving a tool point relative to a workpiece to generate any desired surface of revolution on the latter, said machine comprising, in combination, a base having a spindle and a table thereon, said table being reciprocable relative to said base and to said spindle, a supporting fixture mounted on said table and movable bodily therewith, a support deck on said fixture and disposed for relative movement with respect thereto along coordinate axes, said support deck being adapted to carry a tool and a workpiece alternatively, a hydraulic actuator on said fixture, a pair of cams operated by said hydraulic actuator, and a pair of cam followers, one follower for each cam, one of said followers being connected to said supporting fixture and the other to said support deck, each said cam and its associated follower being constructed and arranged to impart various predetermined combinations of velocity components to said support deck along said coordinate axes.

4. In a boring and turning machine, the combination comprising a base, work rotating means fixed to said base, a table slidably mounted on said base, a first hydraulic actuator adapted to reciprocate said table, a fixture bed rigidly secured to said table, said bed having guideways thereon, a first slide mounted for reciprocation along said guideways, said first slide also having guideways therein running generally transversely of the guideways on said bed, a cross slide mounted for reciprocation along the guideways of said first slide, said cross slide presenting a tool support deck, a cam shaft journaled in said first slide, a first cam fixed to said cam shaft, a follower on said bed, spring means for urging the profile of said first cam into contact with said follower, a second cam fixed on said cam shaft, a second follower mounted on said cross slide, spring means for urging the profile of said second cam into contact with said second follower, a second hydraulic actuator, said second actuator being carried by said first slide, a reciprocable member slidably housed within said second actuator, means positively connecting said reciprocable member with said cam shaft for rotation thereof, solenoid control valves operatively associated with said hydraulic actuators, a manual switch for initiating traversing movement of said table through one of said solenoid valves, switch means responsive to the traversing movement of said table for initiating the operating cycle of said cams through another of said solenoid control valves, and additional switch means operable by said cams for initiating retraction of said table upon completion of said operating cycle, said second switch means being adapted to actuate said one of said solenoid control valves.

5. In a boring and turning machine, the combination comprising a base, means on said base for rotating a workpiece, ways on said base, a fixture supporting table slidably mounted on said ways, a tool supporting fixture on said table and including a first slide movable in a line at an angle of less than 90° to the line of movement of said table and a second slide movable in a line at an angle to the movement of said first slide, one of said slides being superimposed upon the other, a tool point carried on the superimposed slide and adapted to be moved responsive to the movement of each of said first and second slides, rotary cam means for moving said first slide, rotary cam means for moving said second slide, hydraulic drive means common to both said cam means to simultaneously rotate the same in timed relation, additional hydraulic drive means for bodily moving said table and said fixture alternatively between an idle position and a working position, valve means for controlling said table drive means, valve means for controlling said cam drive means, electrical means including table and slide position responsive switch means for controlling the timing and sequence of operation of said valve means whereby to execute sequentially a predetermined series of movements of the said table and cam drive means, electric switch means automatically actuated at approximately the conclusion of the predetermined series of movements of said drive means to effect immobilization of the drive means at the ends of their respective final movements in the said sequence, manually operable switch means for instituting such a predetermined series of sequential events, and a source of hydraulic fluid under pressure to actuate said table and cam drive means.

6. A supporting fixture for use with a boring and turning machine having a longitudinally slidable table and comprising the combination of a bed attachable to the table in fixed relation therewith, a longitudinal slide mounted for reciprocation with regard to the table and to said fixture bed, a cross slide mounted for reciprocation on said longitudinal slide and in a direction transverse to the sliding movement of the latter, a vertically disposed cam shaft, a first cam secured to said cam shaft for rotation thereby about said vertical axis, cam follower means engaging the profile of said first cam, said first cam and said follower being interposed between said fixture bed and said longitudinal slide with said cam follower connected to said longitudinal slide to reciprocate the same on said table, a second cam secured to said cam shaft for rotation thereby about said vertical axis, cam follower means engaging the profile of said second cam, said second cam and said last mentioned follower being interposed between said longitudinal slide and said cross slide with said last mentioned follower connected to said cross slide to reciprocate the same on said longitudinal slide, and a hydraulic actuator on said longitudinal slide for rotating said cam shaft and the first and second cams thereon about said vertical axis.

7. A supporting fixture for imparting to a tool point or a workpiece controllable velocity components along coordinate axes to generate any predetermined surface of revolution in the workpiece, said fixture comprising, in combination, a bed having guideways thereon, a longitudinal slide mounted for reciprocation along said guideways, said longitudinal slide also having guideways therein running generally transversely of the guideways on said bed, a cross slide mounted for reciprocation along the guideways of said longitudinal slide, a cam shaft journaled in said longitudinal slide, a first cam fixed to said cam shaft, a follower on said bed, resilient means for

maintaining the profile of said first cam in contact with said follower, a second cam fixed on said cam shaft, a second follower interposed between the profile of said second cam and said cross slide, resilient means for maintaining the profile of said second cam in contact with said second follower, a hydraulic actuator carried by said longitudinal slide, and a driving connection between the movable member of said actuator and said cam shaft.

8. In a supporting fixture for imparting to a tool point various combinations of movements along coordinate axes to generate any desired surface of revolution in a relatively rotatable workpiece, the combination comprising a bed having guideways thereon, a first slide mounted for reciprocation along said guideways, said first slide also having guideways therein running generally transversely of the guideways on said bed, a cross slide mounted for reciprocation along the guideways of said first slide, said cross slide presenting a tool support deck, a cam shaft journaled in said first slide, a first cam fixed to said cam shaft, a follower on said bed, spring means for urging

the profile of said first cam into contact with said follower, a second cam fixed on said cam shaft, a second follower on said cross slide, spring means for urging the profile of said second cam into contact with said second follower, a hydraulic actuator carried by said first slide, a reciprocable member slidably housed within said actuator, a pinion on said cam shaft, and a rack fixed to said reciprocable member of said actuator, said rack being disposed in meshing engagement with said pinion for actuation of said cam shaft.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,159,207	Godfriaux	May 23, 1939
2,380,808	Tyson	July 31, 1945
2,392,074	Wasson	Jan. 1, 1946
2,421,655	Seyferth et al.	June 3, 1947

FOREIGN PATENTS

Number	Country	Date
561,727	Great Britain	June 1, 1944